

The 2nd AIAA Aeroelastic Prediction Workshop

AePW-2
AIAA SciTech

January 2016
San Diego, CA

Agenda:

- Attached & separated flow cases
- Best practices for unsteady simulation
- Flutter analysis benchmarking
- Benchmark supercritical wing configuration
- Transonic & Subsonic analysis conditions

Sponsored by AIAA Structural Dynamics Technical Committee

Tweet to:
#Unsteady Coupling

Website address:
<http://nescacademy.nasa.gov/workshops/AePW2/public/>

Telecon agenda, May 7, 2015

- Review April telecon notes
 - Review developments since April telecon
 - Reynolds number correction to Case 1
 - Units correction to spring constants
 - Administrivia
 - Updated analysts list
 - AIAA communications
 - Workshop process
 - Proposal to have a face-to-face gathering at AIAA Aviation Conference in June
 - Analysis results, issues that analysts want to discuss
-
- Next telecon **June 11, 11 a.m.** (this telecon will be held 1 week later in the month than normal)

April telecon summary

- Held on April 2, 2015 11 a.m.
- Next telecon May 7, 11 a.m. East Coast time in U.S.
- Updated analysis parameters matrix; uploaded to website
- Experimental data was added to website
- List of analysis teams produced
- Discussion of workshop dates
- Experimental data reduction showing “divot” in the FRFs to likely be physical
- Pawel showed animation of flutter solution at Mach 0.74 using FUN3D

Updated analysis parameter table

Table 1. BSCW analysis input parameters for AePW-2, updated May 4, 2015.

Parameter	Symbol	Units	OTT Configuration	PAPA Configuration	OTT Configuration
Mach	M		0.7	0.74	0.85
AoA	α	<i>deg</i>	3°	0°	5°
Reynolds number (based on chord)	Re_c		4.560x10 ⁶	4.450x10 ⁶	4.491x10 ⁶
Reynolds number per unit length	Re	Re_c/ft	3.456x10 ⁶	3.338x10 ⁶	3.368x10 ⁶
Dynamic pressure	q	<i>psf</i>	170.965	168.800	204.197
Velocity	V	<i>ft/s</i>	387.332	375.700	468.983
Speed of sound	a	<i>ft/s</i>	553.332	506.330	552.933
Static temperature	T_{stat}	<i>F</i>	85.692	89.250	87.913
Density	ρ	<i>slug/ft³</i>	0.00228	0.002392	0.001857
Ratio of specific heats	γ		1.113	1.136	1.116
Dynamic viscosity	μ	<i>slug/ft-s</i>	2.58x10 ⁻⁷	2.69x10 ⁻⁷	2.59x10 ⁻⁷
Prandtl number	Pr		0.683	0.755	0.674
Test medium			R-134a	R-12	R-134a
Total pressure	H	<i>psf</i>	823.17		757.31
Static pressure	p	<i>psf</i>	629.661		512.120
Purity	X	<i>%</i>	95	95	95
Ref. molecular weight based on 100% purity	M	<i>g/mol</i>	102.03	120.91	102.03
Sutherland's constant	C	R	438.07	452.13	438.07
Reference viscosity	μ_{ref}	<i>lb-sec/ft²</i>	2.332x10 ⁻⁷	2.330x10 ⁻⁷	2.332x10 ⁻⁷
Reference temperature	T_{ref}	R	491.4	491.4	491.4

Correction to units for stiffnesses on the website

EXPERIMENTAL UNSTEADY PRESSURES AT FLUTTER ON THE SUPERCRITICAL WING BENCHMARK MODEL

Bryan E. Dansberry, Michael H. Durham*, Robert M. Bennett**, José A. Rivera*, Walter A. Silva*, and Carol D. Wieseman*; Structural Dynamics Division, NASA Langley Research Center, Hampton, VA 23681-0001 and David L. Turnock* Lockheed Engineering and Sciences Corporation

Table 2. Properties of Rigid-Body Modes

	Plunge mode	Pitch mode
Frequency	3.33 Hz	5.20 Hz
Stiffness	2637 lb/ft	2964 ft-lb/rad
ζ	0.001	0.001
Generalized mass	6.1 slug-ft ²	2.7 slug-ft ²

NASA Technical Memorandum 4457

Physical Properties of the Benchmark Models Program Supercritical Wing

Bryan E. Dansberry, Michael H. Durham, and Robert M. Bennett
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Hampton, Virginia

David L. Turnock
Lockheed Engineering & Sciences Company
Hampton, Virginia

Walter A. Silva and José A. Rivera, Jr.
Langley Research Center
Hampton, Virginia

NASA
National Aeronautics and
Space Administration
Office of Management
Scientific and Technical
Information Program
1993

Table 2. Wind-off characteristics of primary modes.

	Frequency	Stiffness	Structural Damping, g	Generalized Mass
Plunge	3.32 Hz	2637 lb/ft	0.002	6.1 slugs
Pitch	5.25 Hz	2964 ft-lb/rad	0.002	2.7 slug-ft ²

- $K_h = 2637 \text{ lb/ft} = 219.75 \text{ lb/in} = \mathbf{219.75 \text{ slinch/sec}^2}$
- $K_\theta = 2964 \text{ ft-lb/rad} = 35568 \text{ in-lb/rad} = \mathbf{35568 \text{ slinch-in}^2/\text{s}^2/\text{rad}}$

Thanks to both Kartik and Daniella for pointing this out.

Please let me know if you see it incorrectly in any of the other posted information sources.

AePW-2 Analyses/Commitments to date (5/29/2015)

Analysis Team	Code	POCs	Email contact
Technion - IIT	EZNSS	Daniella Raveh	daniella@technion.ac.il
FOI	EDGE	Adam Jirasek, Mats Dalenbring	adam.jirasek@gmail.com
NASA	SU2	Dave Schuster	David.m.Schuster@nasa.gov
NASA	FUN3D	Pawel Chwalowski, Jennifer Heeg	Pawel.Chwalowski@nasa.gov , Jennifer.heeg@nasa.gov
Brno University of Technology, Institute of Aerospace Engineering Czech Republic	EDGE	Jan Navratil	navratil@fme.vutbr.cz
NLR		Bimo Pranata	bimo.prananta@nlr.nl
NLR	NASTRAN	Bimo Pranata	bimo.prananta@nlr.nl
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Istanbul Technical University	SU2	Melike Nikbay	'nikbay@itu.edu.tr
ATA Engineering	LowPsiChem	Eric Blades	eric.blades@ata-e.com
Embraer S.A.	CFD++,ZTRAN , NASTRAN *	Guilherme Ribeiro Begnini	guilherme.benini@embraer.com.br
Politecnico di Milano	Various codes	Sergio Ricci	sergio.ricci@polimi.it
AFRL	FUN3D	Rick Graves	Rick.Graves@us.af.mil
Mississippi State	MAST	Manav Bhatia	Bhatia@ae.msstate.edu
Zurich University of Applied Sciences (ZHAW, ZUAS)	EDGE, SU2	Marcello Righi	rigm@zhaw.ch
General Atomics Aeronautical Systems	FLUENT/ANSYS	Askar Konkachbaev	askar.konkachbaev@ga.com
ANSYS	ANSYS Fluent, ANSYS CFX, ANSYS Mechanical	Balasubramanyam Sasanapuri (Krishna Zore, Thorsten Hansen, Michael Tooley, Eric Bish)	balasubramanyam.sasanapuri@ansys.com
University of Strasbourg		Yannick Hoarau (Jan Vos)	Hoarau hoarau@unistra.fr

AIAA Interactions

Approved and signed off by
Bruce Willis, Chairman of Structural Dynamics Technical Committee
Megan Scheidt, Managing Director of Products and Programs



Agreement for Organizing a Workshop at an AIAA Event

This document outlines the specifications and expectations for organizing a workshop at an AIAA event.

General

- Workshop Name: 2nd AIAA CFD Aeroelastic Prediction Workshop (AePW-2)
- Associated Event: SciTech 2016
- Location: Manchester Grand Hyatt, San Diego, CA
- Dates: 2-3 January 2016 (3-6 pm on 2 January, 8 am-6 pm on 3 January)

Logistics

AIAA will provide the following items for the workshop:

- Meeting Space: AIAA will provide 1 room that accommodates 75 people classroom-style seating
- Audio/visual Equipment: Projector, screen, podium, pointer, microphone (both lapel and free-standing)
- Catering: Continental breakfast with beverage service (water, coffee/tea, juices) and afternoon snack with beverage services (water, coffee/tea, sodas)
- Other: Padfolios for workshop attendees

Registration

Registration for the workshop will be handled using AIAA's standard approach:

- The workshop registrations fees will be: \$260 early/\$360 onsite.

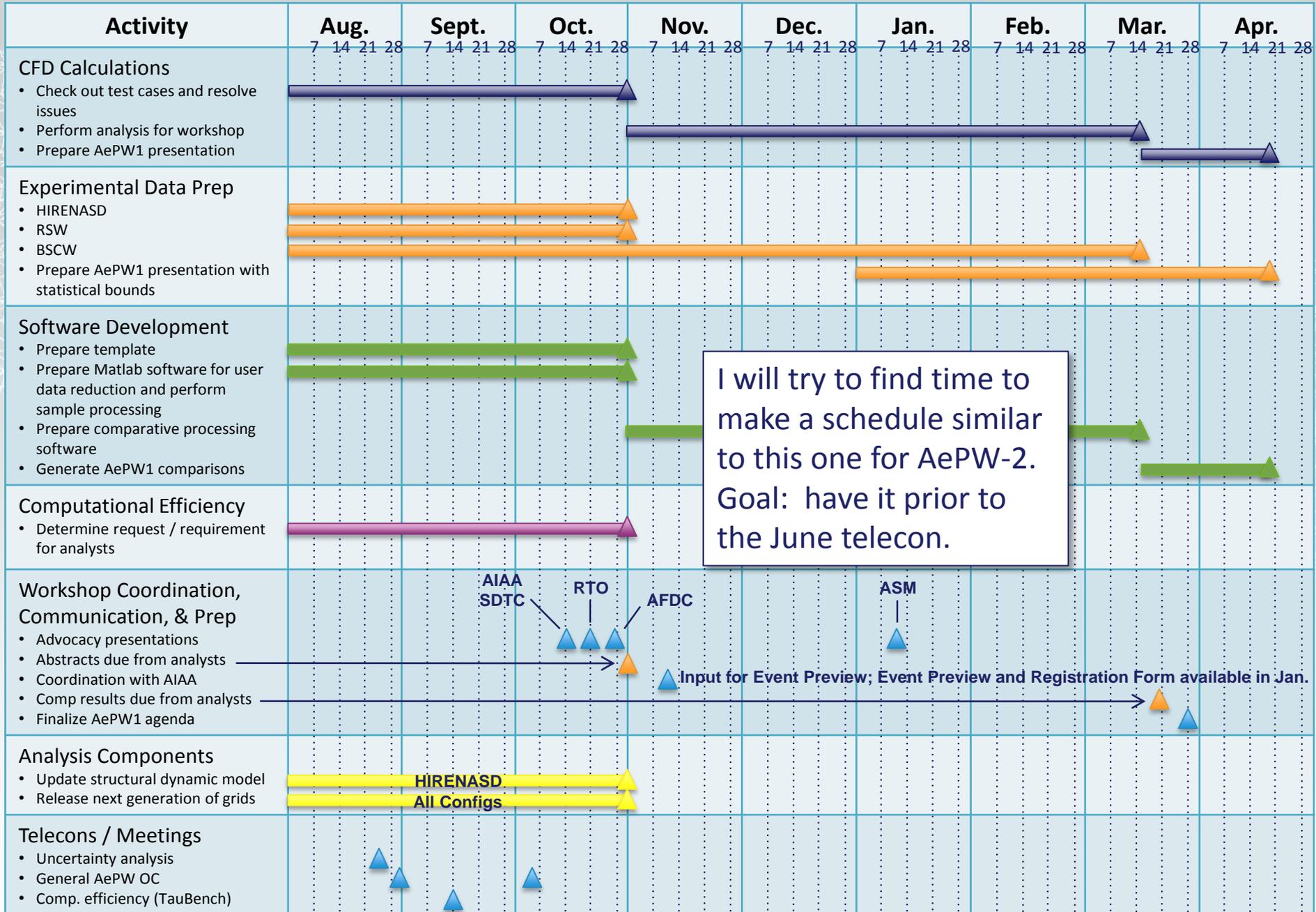
Envisioned Workshop Process for Analysis Teams

- Perform analyses
- Submit results
- Prepare informal presentations for workshop
- SciTech 2016
 - AePW-2
 - Present results
 - Results comparisons
 - Discussion of results
 - Path forward
 - Panel discussion???
- Re-analyze
- Publish at special sessions of conferences (which conferences?)
- Publish combined journal articles

AePW-2 Agenda Thoughts

- Incorporate fresh perspectives in how we organize the workshop
- Following past workshops:
 - Introductory material
 - Welcome & overview
 - Experimental data set
 - Geometry & grid system overview
 - Participant presentations
 - Workshop data summary & discussion
 - Path forward, re-analysis discussions
- Propose a roundtable discussion (1 hour? 2 hours?) for the SciTech conference a few days after the workshop
 - Brief overview of the activity
 - Summary of the data comparisons
 - Panel containing willing and eager analysis team members

AePW1 Prep Schedule: August 2011 – April 2012



We invite you to participate

Participation is unrestricted

Important Dates

- Kickoff Meeting: SciTech 2015
- Workshop: SciTech 2016
- Computational Results Submitted by Nov 15, 2015
- Computational Team Telecons: 1st Thursday of every calendar month 11 a.m. EST

Face-to-Face Meeting at Aviation Conference ???



Action Items

- ALL: Send email with proposed conferences for special sessions in 2016-2017
- ALL: Ponder workshop framework; email suggestions or broach them as discussion topics on the next telecon
- ALL attending AIAA Aviation Conference in June: Plan face-to-face meeting?
- JEN: Generate a fancy schedule of events

March telecon summary

- **Website address:** <http://nescacademy.nasa.gov/workshops/AePW2/public/>
- Held on March 12, rather than March 5 (with the usual March daylight savings time issues)
- Next telecon April 2, 11 a.m. East Coast time in U.S.
- SU-2 doesn't have existing FSI capability.(Melike and Dave Schuster to talk about this?)
- Block-structured grids from AePW-1 are available, generated by Thorsten Hansen at ANSYS. (Thorsten and Pawel will work together to make those available on the new website.)
- The molecular weight of R-134a isn't the same as a standard property table shows (102 g/mol). The value derived using the listed properties is more like 98 g/mol. This is due to the practical issue of gas purity that is achieved in the wind tunnel. The values on the table are from the test data, where the purity was likely 95%'ish. (Pawel will add a line for molecular weight to the analysis parameters table.)
- Add the following to the table of analyses:
 - ATA Engineering (Eric Blades will run LoPsiChem)
 - AFRL (Rick Graves will run FUN3D)
 - Milano Polytechnico (Sergio Ricci will run numerous codes)
- Please send comments regarding the distributed slides. In particular, are you okay with the abstract submittal form?
- With regard to submitting data to the workshop for comparison:
 - Can you provide results in matlab?
 - How do you feel about providing them in a data structure in matlab?
- **Doublet lattice aeroelastic solution results:**
 - Bimo and Jen will work to present the results to date at the next telecon
 - We will put the bulk data file, including the aero model and the flutter cards on the web site. This can serve as a basis for those who might want to use correction methods, etc.
- **Temporal convergence results**
 - Organizations may not have the resources to perform the temporal convergence study for all grids. It is suggested that this be done for a grid resolution where things look to be spatially converged. Experience at NASA has shown qualitatively different results for the unstructured coarse grid than those observed for the finer grid resolutions.
 - The flutter results at low Mach number (Mach 0.74) have shown great variation with regard to time step size. The predicted aeroelasticity stability of the system has been shown to be a function of the time step size and the subiteration convergence level.

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Experimental data analysis presented on April telecon:

Summary of AePW-2 Case 1 analysis

There is energy being transferred from 10 Hz to the superharmonics (20 and 30 Hz) for the sensors near the shock.

Currently, it appears to be physical, not mathematical (i.e. NOT a function of the Fourier analysis parameters chosen.)

The divot occurs for the sensor that is transferring the most energy to the other frequencies. This appears to be a good case for NOT using Fourier analysis methods to analyze and compare the data.

Questions

- Is this a one-time event? i.e. is this an anomaly that we should ignore? i.e. Delete the data point from the FRF distribution?
- Does this occur at adjacent experimental points?

Point 863 is the AePW-2 Case 1 data point

Point	Mach	α , degs	Qbar, psf	Freq of oscillation, Hz	Amplitude of oscillation, degs	Run #
863	0.7	3	170	10	1	15
529	0.7	3	100	10	1	10
860	0.7	3	170	5	1	15
864	0.7	3	170	15	1	15
849	0.7	1	170	10	1	15
868	0.7	5	170	10	1	15

Summary of “adjacent” point analyses

- For cases at Mach 0.7, qbar 170 psf, aoa = 3 degs, the same “divot” behavior is observed
 - 10 Hz
 - 5 Hz
 - 15 Hz
- For the cases at identical Mach, qbar and forcing frequency (10 Hz), the other angles of attack show behavior that makes the baseline case’s divot a logical point in a trend
 - $\alpha=1^\circ$
 - $\alpha=5^\circ$
 - $\alpha=10^\circ$
- For the qbar 100 psf case, there was no divot in the FRF magnitude
- Varying and/or optimizing the Fourier analysis parameters didn’t make large qualitative changes to the FRFs.

Feb Telecon Notes

- Attendees list (to be added)
- Suggested adding to website:
 - Participating teams and matrix with contact information
 - Experimental data (Action item taken by Jen.)
- Request made that the frequency response function information be available in both rectangular form (Re and Im components) as well as in polar (Mag and phase) form. (Action item taken by Jen.)
- Experimental results for Case 1. In the FRF magnitude, there is a sawtooth near the leading edge. What is the source of that? Physical? Sensor issue? (Action item taken by Jen.)
- Grids: structured grids were generated by NASA in plot3D format using Pointwise. The gridding guidelines still include the RSW and HIRENASD from AePW-1. Need to revise them so that they are not confusing. Revisit them also with regard to the Reynolds number.
- Nonlinear effects and LCO:
 - Discussion regarding hysteresis and identification of the neutral stability point
 - Discussion about experimental data sets, including a DLR study on LCO where there were trends with Mach number
- Process:
 - Think about what questions we are trying to answer
 - How do we tell the organizing committee that we are participating by performing analyses? Is there a website sign up or abstract submittal form that we mail?
- Note: following the end of the telecon, as the webex window was closing... it was noted that there were some questions and/or comments on the webex communication window. Apologies for not noticing them. The window closed before we could stop it. We are not smart enough to figure out the now-erased questions. Can you ask them again?
- Next telecon March 5, 11 a.m.

Mini-abstract from AePW-1

MRL and USF Contribution to AePW - 1

N. N. Thusiast_{_}

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Soar N. Air†

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We intend to participate in the AePW-1, to be held April 21-22 2012 in Honolulu, HI. We plan to perform the following sets of computations:

Configuration 1 – RSW , Steady Case, i. $M=.825$, $\alpha=2$ deg

Code: RANS-CFD-3D

Grid: Str-OnetoOne-C-v1 (supplied by AePW-1 committee)

Turbulence model: Menter SST

Configuration 1 – RSW , Unsteady Case, i. $M=.825$, $\alpha=2$ deg, 10 Hz Same as above

Configuration 2 – BSCW, Steady case, $M=.85$, $\alpha=5$ deg, 10 Hz Same as above

Configuration 2 – BSCW, Unsteady case, $M=.85$, $\alpha=5$ deg, 20 Hz Same as above

Configuration 3 - HIRENASD Configuration, steady, $M=.8$, $Re=7$ million, $\alpha =1.5$ deg

Code: RANS-CFD-3DAe

Grid: Str-OnetoOne-C-v1 (supplied by AePW-1 committee)

Turbulence model: S-A

We plan to submit our results electronically by the March 20, 2012 deadline to the AePW-1 committee. RANS-CFD-3DAe is a Reynolds-averaged Navier-Stokes code developed by Et et al.,¹ widely used at the

Multielement Research Lab. It is specifically formulated to work on three-element wing configurations. It uses point-matched grids, and is an upwind finite-volume structured code.

LES-CFD-3D is a large-eddy simulation code developed at the University of Southern Flight.² It employs 6th order central differencing in space and 3rd order temporal differencing, along with 9th order explicit filtering.

References

Et, H., Cet, P., and Era L., "Description of RANS-CFD-3D," Journal of Codes, Vol. 6, No. 5, 1994, pp. 5– 21.

Author, A. and Author B., "Description of LES-CFD-3D," Journal of Lengthy Papers, Vol. 9, No. 2, 2008, pp. 22–1021.

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